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ON THE ACTION OF HARD* WATERS UPON LEAD.

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It is, and has long been, currently believed—1. That where there is free access of atmospheric air, pure or soft waters—that is, waters absolutely or comparatively free from saline ingredients, readily corrode lead and become impregnated—sometimes to a poisonous degree—with some of the salts thereof. 2. That the rapidity and extent of this solvent or corrosive action are proportionate to the purity of the water—that is, its freedom from neutral salts. 3. That impure or hard waters, that is waters containing a considerable amount of neutral salts, do not so affect, or become impregnated with, lead. 4. That such waters are prevented from acting on lead by, or in virtue of, their saline constituents, which exert a sort of protective or preservative power in regard to the lead. 5. That, if a given water does not, within a short period, cause a white coating on freshly burnished lead plates or rods, it may be regarded as destitute of any corrosive action, and may therefore be safely allowed to be kept in cisterns, and transmitted through leaden pipes.

Observation, experiment, and inquiry have led me to the following somewhat opposite conclusions:—1. That certain pure or soft waters *do not* act upon lead. 2. That certain impure or hard waters, in some cases containing abundance of the very salts which are generally regarded as most protective or preservative, *do act* upon lead. 3. That the rationale of the action in these anomalous or exceptional cases is very imperfectly understood. 4. That experimentation on the small scale, and for short periods, is most fallacious, and frequently dangerous, in regard to the conclusions thence to be drawn. 5. That water may, under certain circumstances and to certain extents, contain lead without necessarily being possessed of appreciable poisonous action on the human system. 6. That water contaminated with lead may deleteriously affect certain members or individuals only of a community, family, or household. 7. That the use of water so contaminated is the obscure cause of many anomalous colicky and paralytic affections.

The remarks which follow are intended to be purely suggestive; they are meant chiefly to introduce to the notice of the chemical section of the British Association the fact that the rationale of the non-action of certain soft waters, and of the action of certain hard waters, on lead is very imperfectly understood. The subject of the action of waters upon lead is not at all in a satisfactory state; and in these days of sanitary legislation, when we are boasting of our acquirements in sanitary science, this is an *opprobrium scientiæ* and an *opprobrium medicinæ* which should no longer be permitted to exist. Chemists are totally at variance; when they agree they chiefly agree in what I believe to be error; their analyses are most contradictory, and their theories still more so. In order to place this fact prominently before the reader, I need make but a few citations.

"Numerous attempts," says Dr. Medlock, "have been made by some of the most able chemists to arrive at a correct solution of this important question; but it will be admitted that all their attempts have hitherto failed, and that the conclusions arrived at are unsatisfactory in the extreme. Dr. Noad examined three waters, which were known to act strongly upon lead. The first was taken from a deep well in the neighbourhood of Highgate churchyard, and was found to contain 100 grains of solid matter in a gallon, of which 57 grains consisted of the nitrates of lime and magnesia. The second water, from a spring at Clapham, contained 77·74 grains of solid matter in a gallon, consisting of salts of lime, magnesia, potash, and soda, with 4·10 grains of organic matter. The third water, which was found to act upon lead, was that from the deep wells of London. This water contains about 68 grains of solid matter in a gallon, consisting chiefly of the salts of potash and soda, with very little carbonate of lime or organic matter. These waters differ widely in their chemical composition. In the first nitrates prevail, in the second organic matter, and in the third alkaline carbonates. The action of the first on lead he attributes to nitrates; that of the second to organic matter; and that of the third to free alkali! Dr. Smith, who investigated the action of the waters of the Dee and Don on lead, found that the quantity of lead dissolved increased with the time the water remained in contact with the metal. He considers the action of these waters on lead to be due to the quantity of air dissolved in them."*

It may admit of a doubt whether the opinion of Dr. Lambe, of Warwick, that all natural waters must be held to act upon lead,† which therefore is at all times, and in all circumstances, a dangerous metal to have in contact with drinking water, is not safer, so far as the public health is concerned, than the more modern idea, that a small quantity of certain neutral salts in water acts invariably as a preventive to its action on lead. I have no desire to create unnecessary alarm; but I have a desire that chemistry should be more creditably represented in its relation to sanitary science than it at present is in reference to the action of drinking waters on lead.

In regard to the desirableness of a thorough knowledge of the chemistry of the phenomena in question, I need here say nothing. The action of drinking and culinary waters on lead is a subject of too great moment to the national health to be lightly considered. Few of our standard writers on Chemistry, Materia Medica, or Public Hygiene, omit reference to this subject. But unfortunately many errors may have crept into their works; and these errors have been the means of disseminating false views, not only among the public, but also among the medical profession. Statements of the most opposite kinds will be found in our most familiar text-books on Chemistry and Materia Medica; and this is the more curious and extraordinary, inasmuch as they all profess to borrow or quote from the admirable researches entered upon and published by Professor Christison, of

* I use the term *hard waters* to indicate waters containing an easily appreciable amount of neutral salts, especially of the carbonates, sulphates, and chlorides of lime and magnesia. Under this head a large proportion of spring waters is to be classed. The term is employed in contradistinction of *pure* or *soft* waters, which either contain no saline ingredients, or a very small proportion: such are rain, snow, and many river waters. I think it necessary thus to define my meaning, because I have found that there is frequently great difference of opinion between professional and non-professional persons as to what is, or constitutes, hard or soft water. A water, in reference to which I will immediately have occasion to make some statements, was reported upon by the analyst, an English chemist of repute, as "very soft," while the user of the water, a lady of great intelligence and experience, described it to me as decidedly hard. Professor Christison considers a water soft which contains less than $\frac{1}{5000}$ part of its weight of saline ingredients; hard if it contains more than $\frac{1}{4000}$; mineral if more than $\frac{1}{2000}$. Soft water has the property of forming a lather with soap, and it is suitable for washing purposes, neither of which properties does hard water possess.

† Read before the Chemical section of the British Association, Leeds Meeting, 24th September, 1858.

* "On the Action of certain Waters upon Lead;" Record of Pharmacy and Therapeutics of General Apothecaries' Company, London. Part 2, p. 33. 1857.

† Dr. Lambe, of Warwick: Researches into the Properties of Spring Waters, 1803, quoted in Dr. Christison's Treatise on Poisons, 1835.

Edinburgh, now many years ago. It is true that this gentleman lays down, as a general rule, that pure waters corrode, and become contaminated with, lead; a certain proportion of some saline matters, however, exercising a protective influence, and preventing such contamination. But, as I read and understand the narrative of his experiments and the statements of his conclusions, he appears to me to admit fully and freely that there are exceptional cases of the nature mentioned in my propositions.* These exceptional cases are not brought so prominently under notice in his various publications on the subject as they deserve to be, nor are they in general satisfactorily explained. But I think that Professor Christison has been very unfairly quoted, nay, frequently mis-quoted, by compilers, who have never taken the trouble to investigate the matter for themselves. In some text-books the statements made are absolutely erroneous; in others they are too dogmatic and positive,—general rules only being laid down, and exceptions, which are of the utmost importance, being omitted. In order to illustrate the errors of omission or commission to which I have just adverted, I will cite a very few quotations from well-known works on chemistry or materia medica. Professor Graham says†—"Rain or soft water cannot be preserved with safety in lead cisterns, owing to the rapid formation of a white hydrated oxide at the line where the metal is exposed to both air and water: the oxide formed is soluble in pure water, and highly poisonous. But a small quantity of carbonic acid, which spring and well water usually contain, arrests the corrosion of the lead by converting the oxide of lead into an insoluble salt, and prevents the contamination of the water." Dr. Graham professes to quote from the conclusions of Professor Christison: but the above two sentences contain several statements at variance with the results arrived at by the latter gentleman, and by the majority of experimenters on this subject. The crust or film produced by the action of pure water on lead is neither a simple hydrated oxide nor a simple carbonate, but a permanent compound or mixture of both,—in the proportion, according to Professor Christison, of two equivalents of the latter to one of the former. Where the water contains saline matters, in the deposit are generally found, in addition, the sulphates and chlorides and other salts of lead. Carbonic acid in the water, so far from preventing contamination, assists it, according to Professor Daniell and others, by dissolving a portion of the precipitated carbonate of lead. The carbonic acid, which is the source of the metamorphosis of the hydrated oxide of lead into carbonate, is generally derivable from the atmosphere, not from the water, and this agent operates more powerfully in pure than in hard water. Professor Fyfe, of Aberdeen, in a somewhat extraordinary paragraph,* remarks—"Water, when pure, has no action with lead; but if it be admitted, the metal is slowly oxidated and dissolved. The action goes on more quickly when spring water is employed, the presence of the minute quantity of saline matter in it favouring the action. Hence the corrosion of leaden cisterns and pipes conveying water!" It is needless here to point out how completely at variance with the truth these statements are. So entirely are matters reversed, that it would almost appear as if there were some typographical error! Again, Sir Robert Kane† says—"No danger is, therefore, to be apprehended from the supply of water to a city being conveyed through leaden pipes and preserved in leaden cisterns; for all water of mineral origin dissolves, in filtering through the layers of rocks in its passage to the surface, a sufficiency of saline matter to serve for its protection." Other authors follow Professor Christison more closely and correctly, and make use of more cautious expressions. But here, again, I must prefer the complaint that the exceptional cases, to which I have already referred, are mentioned in so subordinate a way and place that they are apt to be entirely overlooked by the casual reader. Hence the propagation of errors.

In reference to my first proposition, that certain comparatively pure, or what are usually considered soft, waters, do not act on lead, it may be mentioned that Professor Christison‡ found rain water collected on his own house in Edinburgh to be devoid of any corrosive action—a circumstance which he attributes to the presence of alkaline sulphates and chlorides. Again, Professors Graham, Hoffmann, and Miller, who some time ago conducted a Government investigation into the action of waters on lead, with a view to discover "whether any comparative inconvenience would arise from a supply of soft water to the metropolis," contrary to what might have been expected, assert that, "with one exception, neither the soft waters of the Surrey Hills, which have a hardness of only two degrees, nor spring water artificially softened to three degrees of hardness, have any perceptible action on lead. The idea that soft waters invariably act upon lead seems to have its origin in the fact that certain specimens of distilled water, placed in contact with a large surface of bright sheet lead, dissolve as much as six or eight grains of the metal to the gallon."§ Dr. Medlock|| asserts that "perfectly neutral and pure" distilled water, from which nitrate of ammonia has been expelled, has no action upon lead; for, in a gallon of this water, allowed to remain in contact with 560 square inches of lead for forty-eight hours, no trace of lead could be discovered.

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* I append a few quotations or statements from Professor Christison's publications on the subject:—"The action is impeded by the co-existence of any neutral salts in the water; and some salts, whose acids form very insoluble compounds with oxide of lead, prevent the action entirely in very minute quantity."* "Water, which contains less than about $\frac{1}{8000}$ of salts in solution cannot be safely conducted in lead pipes without certain precautions. Even this proportion will prove insufficient to prevent corrosion, unless a considerable part of the saline matter consist of carbonates and sulphates, especially the former. So large a proportion as $\frac{1}{4000}$, probably even a considerably larger proportion, will be insufficient if the salts in solution be in a great measure muriates. It is, I conceive, right to add that in all cases, even though the composition of the water seems to bring it within the conditions of safety now stated, an attentive examination should be made of the water after it has been running for a few days through the pipes. For it is not improbable that other circumstances besides those hitherto ascertained may regulate the preventive influence of the neutral salts."† "When lead has been exposed for a few weeks to a solution of a protecting salt, and has acquired a thin film over its surface, it not only is not acted on by the solution, but is even also rendered incapable of being acted on by distilled water."‡ "Most spring waters, unlike rain or snow water, have little or no action on lead, because they generally contain a considerable proportion of muriates [?] and sulphates."§ "The general result of these experiments appears to be that neutral salts, in various, and for the most part minute, proportions, retard or prevent the corrosive action of water on lead, allowing the carbonate to deposit itself slowly, and to adhere with such firmness to the lead as not to be afterwards removable by moderate agitation, adding subsequently to this crust other insoluble salts of lead, the acids of which are derived from the neutral salts in solution; and thus, at length, forming a permanent and impermeable screen, through which the action of the water cannot any longer be carried on."||

† Elements of Chemistry, vol. ii., p. 111. London, 1858.

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* Dispensary, second edition. 1848. Art. *Plumbum.*

† Trans. Royal Society of Edinburgh, vol. xv., part 2, p. 271.

‡ Treatise on Poisons, 1835, p. 481.

§ Ibid., p. 486.

|| Ibid., p. 483.

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* Elements of Chemistry. Second ed., p. 529. Edinburgh, 1830.

† Elements of Chemistry. Second ed., p. 558. Dublin, 1849.

‡ Treatise on Poisons, 1835, p. 484, "On the Action of Natural Waters on Lead."

§ "On the Action of certain Waters upon Lead," by Dr. Medlock; Record of Pharmacy and Therapeutics, Part II., p. 34; General Apothecaries' Company. London, 1857.

|| Ibid., p. 35.

My second proposition I can illustrate more easily and fully. The illustrations which have presented themselves to my notice have been chiefly of the two following kinds:—1. Corrosion, or erosion, to such an extent as to cause leakage, of cisterns by waters of various degrees and kinds of hardness, or containing various kinds and amounts of neutral salts. 2. The poisonous action of hard or hardish waters impregnated with lead on the human body.

It is needless to multiply instances; two or three must here suffice; but they will probably serve to recall to the memory of many of my readers parallel illustrations. My attention was specially called to the erosion of lead cisterns by spring or well waters about two years ago, by my being requested to examine some cisterns, the bottom lining of which had been repeatedly eroded to the extent of causing leakage, and which had been as repeatedly repaired. These cisterns contained the water supply of a large public institution of which I am the physician. The institution is supplied with water from three different sources, viz.—1. Rain water from the roof; 2. Spring water; and 3. Surface water. With the first I have here nothing to do; it is in reference to the second especially, and also subordinately to the third, that my remarks apply. The spring water is from a deep well on the northern declivity of Kinnoull Hill, penetrating the Old Red Sandstone near where the trap protrudes through it. The water rises in the well to the height of twenty-eight feet. It is good, hard, drinking water, and is used in the institution for drinking, as well as for culinary purposes. The surface water is chiefly rain water, which percolates through the soil, and is collected in a large tank holding 95,156 gallons. This water is used chiefly for baths, water-closets, and general cleansing processes. The cisterns have no covers; they are contained in the attics of the buildings, but are not exposed directly to the external air. My attention was first directed to the cistern containing the spring water. I found the leaden bottom of this cistern scooped out here and there into a series of cavities or holes, some of which were minute perforations, allowing of an escape of the water. Moreover, the bottom was covered by a pretty thick layer or coating of a heavy cream-yellow, putty-like matter, which also filled the cavities or holes above referred to. The cistern was comparatively new. I was told it had been repeatedly thus eroded, and as frequently repaired. But it would appear that the mode of repair had been mere soldering; and this, it is of great importance to bear in mind, inasmuch as I believe this mode of repair to have been the cause of the subsequent more rapid erosion. It has now been abundantly proved that galvanic action occurs in a leaden cistern holding water at the point of contact of the lead with other metals, whether these be in the form of solder or of iron bars, &c.; that this galvanic action is extremely favourable to corrosion; and that it is greatest in waters containing saline matters,—that is, precisely in circumstances in which, were there no galvanic action, the corrosive effect of the water would be least. Similar phenomena had been repeatedly observed in cisterns containing the surface water; and the leakage of these cisterns became a matter of some moment, not only from the expense of constant repairs in comparatively new cisterns, but also from the damage done to the roofs and walls of apartments situated below the attics by the escaped water. Facts bear out what theory would lead us to conclude, that the newer the cistern the more rapid and energetic is the corrosive action of the water on it.

I was naturally led to make an analysis (a rough and qualitative one only, however), with a view to discover precisely the circumstances under which this corrosive action took place. This analysis embraced,—1. The deposit on the bottom of the cistern; 2. The supernatant water in the cistern ; and, 3. The spring water, as drawn from the well before it had traversed iron pipes, or been contained in leaden cisterns. The results were as follow: —The deposit contained carbonates, sulphates, and chlorides of lead, lime, and magnesia; iron in abundance; and faint traces of soda. The supernatant water contained the sulphates, carbonates, and chlorides of lime and magnesia, with traces of soda. The carbonates and chlorides were most abundant—the sulphates less so; lime was plentiful; magnesia was in small quantity. There was no lead; and this is of importance to bear in mind; for it frequently happens that, though lead is found abundantly in the deposit on the bottom of such a cistern, it cannot be detected readily, or at all, in the supernatant fluid. Nor did this water contain distinct traces of iron. The spring water, as drawn directly from the well, contained the same salts of lime, magnesia, and soda, in similar proportion, without lead or iron. The iron found in the cistern deposit was probably dissolved as oxide by the water as it passed through the iron pipes which convey it from the well to the institution; but it may also partly have been derived from the soil. A more careful analysis would probably, however, have detected it in the water of the cistern, and possibly in the water drawn directly from the well, being, in the latter case, derived from the iron apparatus of the pump. Distrustful of my own analysis, I had it repeated more carefully by a friend in Edinburgh.* His results were entirely corroborative of my own more rough and hasty essays. The lead in the deposit was by him converted into sulphate, with a view to ascertain its quantity. Calculating from the weight of the sulphate thus obtained, the deposit was found to contain no less than 43·18 per cent. of lead,—a large amount, to account for which it is right to mention that, in scraping the deposit from the bottom of the cistern, minute portions of metallic lead had been probably included.

Now, the water in question curdles soap with great rapidity and ease, and is therefore decidedly hard. But, in considering the action of water on lead, it is important to remark the nature or kind, as well as the amount, of the neutral salts present in it. The carbonates and chlorides were much more abundant than the sulphates, while lime was plentiful, and magnesia and soda occurred only in small quantity. The water of Airthrey Well, Bridge of Allan, for instance, is said to possess no action on lead; yet it contains no less than $\frac{1}{77}$th part of its weight of salts, which are chiefly sulphates and chlorides.† The experiments of Professors Christison and Taylor, and others, have established that the sulphates and carbonates are among the most protective or preservative salts, while the chlorides are among the least so. There is a difference of opinion among observers as to whether the carbonates or sulphates of lime and magnesia are most strongly protective; but there is no doubt that the sulphate of lime is a powerfully protective salt, while it is also one of the most common ingredients of hard waters. According to Professor Taylor, sulphate of lime is the salt occurring in hard waters, which chiefly prevents their corrosive action on lead; and he describes the coating deposited on the lead as consisting of the sulphate of lead. The results of Professor Christison, as well as a consideration of the chemical theory of the action, would lead to the suspicion that the latter statement is not quite accurate; for it is extremely probable, that not only sulphate, but also the carbonate and hydrated oxide of lead, will at least be found in such deposits. Professor Taylor deduces from his investigations, that a water containing sulphates and lime is not likely to corrode, or become contaminated with, lead, and may therefore be safely used for drinking and cooking.

I made a series of comparative analyses, with a view to ascertain especially the condition as to hardness, or the nature and amount of the saline constituents, as well as the action upon lead, of various waters used for drinking and culinary purposes in and around Perth. The following are briefly the results at which I have arrived,

* Made in June, 1857.

† Christison on Poisons. 1835. P. 486.

—the analyses or experiments in question being only tentative or qualitative,—rough and approximate in character, and not aiming at quantitative accuracy:—

I. Well Waters; decidedly Hard.—The wells, the waters of which were examined, are apparently chiefly sunk in the Old Red Sandstone, near where it is penetrated by the trap mass of Kinnoull Hill.

1. Rosemount, Bridgend, Perth; well 16 feet deep.—*a.* Water drawn from lead pipes in the house, but before entering cisterns; carbonates, sulphates, and chlorides abundant; lime and magnesia also abundant, especially the former; sediment or solid matter, on evaporating to dryness, comparatively large; no lead nor iron.—*b.* Water drawn from cisterns lined with lead, but covered with wood, placed in garrets, and not exposed directly to external air. Had precisely the characters of that described under head *a.*

2. Murray's Royal Institution, Kinnoull Hill, Perth. —West well, at a considerably higher level than the well at Rosemount. Water, after passing through lead or iron pipes, taken from a lead cistern in the Institution, having no cover; sulphates and chlorides abundant, particularly the former; lime abundant; magnesia in small quantity; neither lead nor iron; burnished lead rods immersed in the water which was exposed to the air became tarnished or streaked white with carbonate in four or five days, but the water was not rendered opalescent nor muddy till the end of one month's immersion.

3. Pitcullen House, Bridgend, Perth.—The elevation of the well is intermediate between that of the wells at Rosemount and Murray's Royal Institution; all three being situated on the slope of Kinnoull Hill. The water had precisely the characters of that of the other two wells above described. Burnished lead rods were tarnished in five days, but were not further affected at the end of one month's immersion, at which time, also, the water in which they were immersed was unaffected as to its transparency.

II. Spring Waters; mostly Hard.—The springs referred to appear to rise from the trap of Kinnoull Hill (consisting of basalts, amygdaloids, and tufas, chiefly), at or near where it bursts through the old red sandstone of lower Perthshire. Like the wells above described, these springs are all situated on the declivity of Kinnoull Hill.

1. Bowerswell, Bridgend, Perth.—Carbonates, chlorides, and sulphates abundant, particularly the two former; lime abundant; magnesia in small quantity; sediment or solid matter, on evaporating to dryness, considerable; burnished lead rods tarnished after three days' immersion; no change of transparency of water after one month's immersion.

2. Muirhall Quarry, Kinnoull Hill.—This is an old basalt quarry, at a higher elevation on Kinnoull Hill than any of the springs, wells, or other sources of water supply, which I have described, or am about to describe. There is a perennial spring at the bottom of the quarry, now covered by a mass of water which has accumulated for years. But this mass of water consists, in great measure, of rain water and of surface drainage water from the neighbouring fields. It is a very soft, comparatively pure water. Carbonates plentiful; chlorides and sulphates in small quantity; lime and magnesia also in small quantity; considerable sediment on evaporation; burnished lead rods tarnished by five days' immersion; but transparency of water unaffected at the end of a month.

3. Bridgend Water Company's supply.—Water taken from the stream immediately before it enters the reservoir at New Scone. The water in question flows from, and constitutes the overflow of, the water in the quarry immediately before mentioned. The composition of the water was identical with that of the quarry water, except that there was a small sediment on evaporation. Its action on lead was also precisely similar.

III. Surface or Drainage Water; Hard.—This is chiefly rain water, percolating through the soil; but it is also partly made up of spring water of the characters already described.

1. Murray's Royal Institution, east tank.—Carbonates, sulphates, and chlorides in considerable quantity, especially latter; lime and magnesia also in notable amount, especially former; sediment, on evaporation, considerable; lead began to be slightly tarnished after one night's immersion; but the water remained clear after one month.

IV. River Water; decidedly Soft.

1. Tay River water, taken directly from the river as it flows past Perth. This is the source of supply of the Perth Water Company. It is comparatively pure; and in this respect resembles the water of Muirhall Quarry and the Bridgend Water Compamy. Carbonates, chlorides, and sulphates, in small quantity, especially latter; considerable sediment, chiefly mechanical impurity, on evaporation; lead began to be tarnished after a single night's immersion; it was quite tarnished in four days, but the water was unaffected in its transparency after one month's immersion.

2. Tay River water, drawn from the cistern of the water works, South Inch, after filtration. Water had precisely the characters described under the head IV., No. 1.

V. Rain Waters; very Soft.

1. Pitcullen House; rain water barrel.—No carbonates; almost no chlorides; a trace of lime and sulphates; sediment, on evaporating down, very small, and chiefly mechanical impurity; lead tarnished, and water, in which it was immersed, opalescent after one night. After three nights' immersion the water was full of white pearly crystals of carbonate, which rapidly accumulated by longer exposure.

2. Murray's Royal Institution; rain water cisterns.—No appreciable amount of chlorides, carbonates, lime, nor magnesia; faint traces of sulphates; sediment, on evaporating down, very small, and chiefly mechanical impurity; lead tarnished and water opalescent after a single night's immersion. After five days, lead rod copiously covered with flocculent masses of crystals of carbonate, which also formed a plentiful sediment; they formed more rapidly, and in greater abundance, than in the rain water from Pitcullen House.

It will be observed that all the waters examined possessed some action on lead; though only in the cases of the rain waters was this action apparently dangerous in amount or degree.

It has sometimes been ignorantly believed that deposits in lead cisterns, such as I have described, are the precipitated salts of hard waters, which are themselves the means of corroding the metal; and, under this impression, great care has been taken to scrape away the deposit so as to expose a fresh surface of lead. This procedure, of course, has only had the effect of aggravating the mischief! Again, it has been imagined by those who regard such deposit as consisting wholly or partly of carbonate or other insoluble salts of lead, that the supernatant water cannot possibly contain salts of lead, and cannot therefore possess any poisonous properties. Now, even the carbonate, which is undoubtedly insoluble in pure water, may be held in solution, it would appear, in minute quantity—sufficient, however, to possess poisonous properties—if the water is surcharged, as is frequently the case, with carbonic acid. Further, it is not at all necessary that it be held in solution in order to the development of its poisonous properties, for it may be simply held in suspension in a state of very minute division, in which case there is no doubt of its possessing a poisonous action on the human system. Besides, the hydrated oxide, as well as the chlorides and nitrates, which are frequently, if not always, found in such deposits, are all sparingly soluble in water, and may be, individually or severally, the source of poisonous action. It is sufficiently established, that the chlorides of lime and magnesia are common constituents of spring waters; but it is not perhaps so generally known

that the nitrate—according to some chemists, the *nitrite*—of ammonia, or other nitrates or nitrites, occur frequently in rain, as well as in river and spring waters. The mere transparency of a water cannot be regarded as a proof that no lead exists in it. It may appear perfectly pure, and yet contain dissolved hydrated oxide, or other salts of lead, which are slowly thrown down as white and insoluble carbonate on exposure to the air.

(*To be continued.*)

BRITISH ASSOCIATION, ABERDEEN, 1859.

MERCANTILE STEAM TRANSPORT ECONOMY.

By Charles Atherton, Chief Engineer, Royal Dockyard, Woolwich.

The following paper was read before the Mechanical Section:—

Public usefulness, as dependent upon science, being the great object for which the "British Association for the Advancement of Science" was originated, and has now been signally upheld for 29 years, a period remarkable for the progress that has been made in the utilisation of the powers of nature, to such an extent that the international condition of the globe is now being revolutionized by the progressive practical utilisation of elements which heretofore were regarded merely as phenomena of nature, viz.:—Steam and Electricity; in which revolution the application of steam to the purposes of navigation has played so conspicuous a part, that now, in proportion as steam may be effectively employed in the pursuits of commerce and of war, it is acknowledged that even nations will rise or fall; seeing, moreover, that at no period in the history of steam navigation has so great a step been made in its practical development as may now be said to have been realized by the fearless introduction, in marine engineering, of the long known and well understood effects of increased pressure, superheating, and expansion; the recognition and application of which principles have now, at length, been attended with such effect in marine engineering, that the consumption of fuel with reference to power is now shown to be practically reducible to less than one-half of the ordinary consumption of coal on board ship. Seeing also that mercantile enterprise, setting no limits to speculative investments, has in these days emancipated mechanical intellect from the fetters by which ideas as respects magnitude have hitherto been bound; under such circumstances I cannot doubt that any effort to popularise a knowledge of the practical utilisation of steam, with reference to the consumption of fuel, though advanced with no pretentions to science, beyond that which may be awarded to originality, and labour in the application of calculation to developing useful results, will be favourably received, more especially as the paper which I now beg to present is in continuation and conclusion of an inquiry which has already, in part, on two occasions, been favourably entertained by this Association, and honoured with a place in its published records. The former papers to which I allude are:—1st. "Mercantile Steam Transport Economy, with reference to Speed."—Vol. for 1856, p. 423.* 2nd. "Mercantile Steam Transport Economy, with reference to the Magnitude of Ships and their Proportions of Build."—Vol. for 1857, p. 112.† And I now propose to bring this inquiry to its conclusion by the following paper on:—

Mercantile Steam Transport Economy, as affected by the Consumption of Coals.

My purpose, and the drift of my remarks will, probably, be the more readily understood by my at once adducing the tables C and D, and the diagram E, in continuation of the tables A and B, which are published in the Volume of Transactions for the year 1857, pp. 116 and 119,* observing with reference to these tables C and D, that the rate of consumption of coal on which the calculations are based, viz:—$2\frac{1}{2}$ lbs. per indicated horse power per hour has been practically realized on continuous sea service, although the ordinary consumption of steam-ships in the Royal Navy, as well as in the best

TABLE C.

Calculated for the speed of ten knots per hour, and showing the mutual relation of Displacement, Power, and the consumption of coal per day, hour, and knot, the Co-efficients of Dynamic performance, deduced from the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{ind. h. p.}}$ being assumed to be 250, and the consumption of fuel at the rate of $2\frac{1}{2}$ lbs. per ind. h. p. per hour.

Displacement.	Nominal H.P. taken at the unit 100,000 lbs. 1ft. per min.	Indicated H.P. taken at the unit 33,000 lbs. 1ft. per min.	Coals.		
			Per Day of 24 hours.	Per Hour.	Per Knot.
Tons.	H.P.	Ind H.P.	Tons.	Cwt.	Cwt.
250	52	159	4·26	3·55	·36
300	59	179	4·80	4·00	·40
350	66	199	5·33	4·44	·44
400	72	217	5·81	4·84	·48
450	78	235	6·30	5·25	·53
500	83	252	6·74	5·62	·56
600	94	285	7·63	6·36	·64
700	104	315	8·44	7·03	·70
800	114	345	9·24	7·70	·77
900	123	373	9·98	8·32	·83
1,000	132	400	10·70	8·92	·89
1,100	141	426	11·4	9·51	·95
1,200	149	452	12·1	10·1	1·01
1,300	157	476	12·7	10·6	1·06
1,400	165	501	13·4	11·2	1·12
1,500	173	524	14·0	11·7	1·17
1,600	181	547	14·6	12·2	1·22
1,700	188	570	15·4	12·8	1·28
1,800	195	592	15·8	13·2	1·32
1,900	203	614	16·4	13·7	1·37
2,000	210	635	17·0	14·2	1·42
2,250	227	687	18·4	15·3	1·53
2,500	243	737	19·7	16·4	1·64
2,750	259	785	21·0	17·5	1·75
3,000	275	832	22·3	18·6	1·86
3,250	290	878	23·5	19·6	1·96
3,500	304	922	24·7	20·6	2·06
3,750	318	965	25·8	21·5	2·15
4,000	333	1008	27·0	22·5	2·25
4,250	347	1050	28·1	23·4	2·34
4,500	360	1090	29·2	24·3	2·43
4,750	373	1133	30·2	25·2	2·52
5,000	386	1170	31·3	26·1	2·61
5,500	411	1246	33·4	27·8	2·78
6,000	436	1321	35·4	29·5	2·95
6,530	460	1393	37·3	31·1	3·11
7,000	483	1464	39·2	32·7	3·27
7,500	506	1533	41·0	34·2	3·42
8,000	528	1600	42·8	35·7	3·57
8,500	550	1666	44·6	37·2	3.72
9,000	571	1731	46·3	38·6	3·86
9,500	592	1794	48·0	40·0	4·80
10,000	613	1857	49·7	41·4	4·14
11,000	653	1978	52·9	44·1	4·41
12,000	692	2096	56·2	46·8	4·68
13,000	730	2211	59·2	49·3	4·93
14,000	767	2324	62·3	51·9	5·19
15,000	803	2433	65·2	54·3	5·43
20,000	973	2498	79·0	65·8	6·58
25,000	1129	3420	91·6	76·3	7·63

* See *Journal of the Society of Arts*, Vol. IV., p. 650.

† See *Journal of the Society of Arts*, Vol. V., p. 563.

* See *Journal of the Society of Arts*, Vol. V., pp. 565 and 567.

vessels of the most celebrated steam shipping companies, is, I believe, at the present time, fully 50 per cent. in excess of that amount; and I may say, that in steam shipping generally, the consumption of coals per knot of distance, with respect of displacement and speed, is double the consumption which these tables, based as they are on an example of existing practice, show to be now practically realisable.

The tables now adduced are as follows:—

Table C, calculated for the speed of ten knots per hour, showing the mutual relations of displacement, power, and the consumption of coals per day, per hour, and per knot, for vessels of a gradation of sizes, from 250 tons displacement up to 25,000 tons, the co-efficient of dynamic performance, deduced from the formula $\frac{V^3 \, D^{\frac{2}{3}}}{\text{Ind. h. p.}}$ being assumed to be 250, and the consumption of coals being assumed to be at the rate of 2½ lbs. per indicated h. p. per hour. On these data, the co-efficient with reference to coals deduced from the formula $\frac{V^3 \, D^{\frac{2}{3}}}{w}$ (w) being the consumption of coals per hour expressed in cwts.) becomes 112·10.

Table D (p. 727) showing the mutual relation of displacement, power, and coals consumed per day, per hour, and per knot for the respective speeds of 10, 15, 20, and 25 knots per hour. The data on which this table is calculated being the same as above described for table C.

Diagram E, (p. 728) showing approximately by scale the nautical mileage consumption of coals for vessels from 1,000 tons displacement up to 25,000 tons, deduced from Table D.

It will be observed that in Table C the tabulated sizes of ships, as determined by their respective load displacements, increase progressively from 250 tons displacement up to 25,000 tons, showing, under assumed conditions, which, however, are justified by the present circumstances of realized advancement in steam navigation, the mutual relations of displacement and coals calculated for the speed of ten knots per hour, as most convenient for a standard of reference. The intended practical use of this Table C is to facilitate mercantile investigation into the dynamic merits of steam ships as locomotive implements of burden by comparing their actual consumption of fuel with the calculated consumption of the ship of corresponding size and speed as recorded in this tabulated standard of comparison, whence the constructive merit of ships, as respects their *working economy of fuel, on which the cost of freight so much depends*, may be relatively ascertained. For example, a certain ship of 800 tons mean displacement attains the speed of 8·8 knots per hour, with a consumption of coals certainly not exceeding 4·3 cwts. per hour, or ·49 cwts. per nautical mile or knot; which (as the consumption of coals per knot varies *cœteris paribus* as the square of the speed) is equivalent to ·63 cwts. per knot at the speed of ten knots per hour. Now by referring to Table D we find that on the assumed data therein referred to, the standard ship of 800 tons displacement, steaming at ten knots per hour, would consume ·77 cwts. of coal per knot. Hence, therefore, it appears that the ship referred to in this instance is superior to the tabulated standard in the proportion of ·77 to ·63, that is, in the proportion of 122 to 100, the superiority with reference to the consumption of coals per knot being 22 per cent.

Again, a certain ship of 3,500 tons mean sea displacement makes a voyage of the speed of 12·88 knots per hour, consuming 83 cwts. of coal per hour, or 6·44 cwts. per knot, which, by the law of dynamics above quoted, is equivalent to 3·88 cwts. per knot at the speed of ten knots per hour; but by referring to the Table of comparison C, we find that the standard ship of 3,500 tons displacement, steaming at ten knots per hour, would consume only 2·06 cwts. of coal per knot. Hence, therefore, it appears that the ship referred to in this instance is inferior to the tabulated standard ship in the proportion of 2·06 to 3·88, that is, in the proportion of 53 to 100, the inferiority with reference to the consumption of coals being 47 per cent.

Thus, by reference to this tabulated standard of comparison (C), we have the means of readily deducing the exact per centage by which ships, as respects the dynamic duty performed with reference to the consumption of coals, differ from each other. I need not dwell on the importance of this consideration as affecting the commercial value of ships.

With reference to Table D, showing the mutual relations of displacement, power, and coals consumed per day, per hour, and per knot for the respective speeds of 10, 15, 20, and 25 knots per hour, the object of this table is to show the extent to which the required engine-power, and the nautical mileage consumption of coals are dependent on the rate of speed, thereby facilitating the adaptation of ships as respects their size and power to the service that may be required of them.

For example, by referring to Table D, we observe that a ship of 5,000 tons displacement, steaming at ten knots per hour, requires 1,170 indicated h. p., and consumes 2·61 cwts. of coal per knot; but to steam 15 knots per hour, the same vessel would require 3,947 ind. h. p., and the consumption of coals would be 5·87 cwts. per knot; hence it appears, that to increase the speed from 10 to 15 knots per hour, the power requires to be increased upwards of three times, and the consumption of coals per knot is more than doubled.

Again, let it be supposed that the weight of the hull of a ship of 5,000 tons displacement fitted for sea amounts to 40 per cent. of the displacement, or 2,000 tons, and suppose the weight of the engines and boilers to be one ton for each indicated h. p., the vessel requiring, as shown by Table D, 1,170 indicated h. p. to attain the speed of ten knots per hour, with a consumption of coal at the rate of 2·61 cwts. per knot, then on those data, the engines, to attain the speed of ten knots per hour, would weigh 117 tons, and the weight of coals for a passage of, say 12,000 nautical miles, would be 12,000 $\times$ 2·61 $=$ 31,320 cwts., or 1,566 tons weight, making together, for hull, engines, and coals, 2,000 $+$ 117 $+$ 1,566 $=$ 3,683, and consequently the displacement available for cargo would be 5,000 $-$ 3,683 $=$ 1,317 tons weight. But if it be purposed that the steaming speed shall be at the rate of 15 knots per hour, the required power, as appears by Table D, will be 3,947 ind. h. p., consequently the weight of the engines will be 395 tons, and the maximum displacement available for coals will be 5,000 $-$ 2,395 $=$ 2,605 tons weight, or 52,100 cwt., which, at the tabulated rate of consumption, 5·87 cwts. per knot, would be sufficient only for a passage of 8,876 nautical miles, and this to the utter exclusion of all goods cargo, showing that the ship is inadequate for steaming 12,000 nautical miles at the required speed of 15 knots per hour, though the same ship, if duly fitted with engine-power for steaming at ten knots per hour, would perform the whole passage of 12,000 nautical miles without re-coaling at any intermediate station, and carry 1,317 tons of remunerating goods cargo.

These few examples will, it is hoped, sufficiently illustrate the application and use of Tables C and D in facilitating mercantile inquiry into the capabilities of steam-ships with reference to the all-important question of consumption of coals; but in order still further to facilitate calculations on this subject, the Diagram E has been prepared, whence, simply by inspection, the consumption of coals per knot, at any rate of speed, may be approximately ascertained for vessels from 1,000 tons displacement up to 25,000 tons, the data on which this diagram has been calculated being the same as that on which Tables C and D are based.

The use and application of this Diagram E is evident; it brings the tables under ocular review, and generalises their application. It is given as an example of a system that admits of being more fully and elaborately developed

TABLE D.

Showing the Mutual Relations of Displacement, Power, and Coals consumed per Day, per Hour, and per Knot, for the respective Speeds of 10, 15, 20, and 25 Knots per Hour. The Coefficient of Dynamic Performance being deduced from the Formula $\frac{V^3 D^{\frac{2}{3}}}{\text{ind. h. p}}$ being assumed to be 250, and the Consumption of Coals being assumed to be at the rate of $2\frac{1}{4}$lbs per indicated horse power per hour.

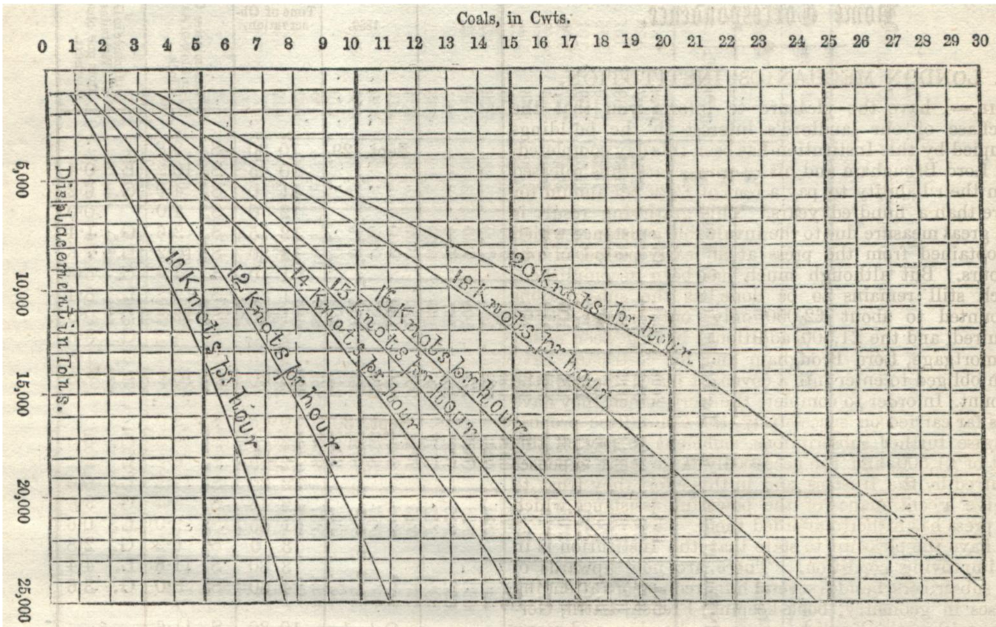
Displacement in Tons, at 35 cubic feet of Sea Water per Ton.	10 Knots.				15 Knots.				25 Knots.				25 Knots.			
	Ind. H. P.	Coals.			Ind. H. P.	Coals.			Ind. H. P.	Coals.			Ind. H. P.	Coals.		
		Per Day.	Pr Hour.	Pr Knot.		Per Day.	Pr Hour.	Pr Knot.		Per Day.	Pr Hour.	Pr Knot.		Per Dap.	Pr Hour.	Pr Knot.
		Tons.	Tons.	Cwt.		Tons.	Cwt.	Cwt.		Tons.	Cwt.	Cwt.		Tons.	Cwt.	Cwt.
1,000	400	10·7	8·92	·89	1350	36·1	30·1	2·0	3200	85·7	71·4	3·57	6250	167	139	5·56
1,200	452	12·1	10·1	1·01	1524	40·8	34·0	2·27	3614	96·8	80·7	4·03	7058	188	157	6·28
1,400	501	13·4	11·2	1·12	1689	45·2	37·7	2·51	4005	107	89·4	4·47	7822	210	175	7·00
1,600	547	14·6	12·2	1·22	1847	49·4	41·2	2·75	4377	117	97·7	4·88	8550	229	191	7·64
1,800	592	15·8	13·2	1·32	1998	53·5	44·6	2·98	4735	126	105	5·25	9248	247	206	8·24
2,000	635	17·0	14·2	1·42	2143	57·4	47·8	3·19	5080	136	113	5·65	9921	265	221	8·84
2,250	687	18·4	15·3	1·53	2318	61·8	51·5	3·43	5495	146	122	6·10	10,731	286	239	9·56
2,500	737	19·7	16·4	1·64	2487	66·6	55·5	3·70	5895	158	132	6·60	11,629	308	257	10·3
2,750	785	22·0	17·5	1·75	2650	70·9	59·1	3·94	6281	168	140	7·00	12,268	328	273	10·9
3,000	832	21·3	18·6	1·86	2808	75·2	62·7	4·18	6656	178	148	7·40	13,000	348	290	11·6
3,250	878	23·5	19·6	1·96	2962	79·3	66·1	4·40	7021	188	157	7·85	13,715	367	306	12·2
3,500	922	24·7	20·6	2·06	3112	83·3	69·4	4·63	7377	197	164	8·20	14,408	385	321	12·8
3,750	965	25·8	21·5	2·15	3259	87·2	72·7	4·85	7724	206	172	8·69	15,086	404	337	13·5
4,000	1008	27·0	22·5	2·25	3402	91·1	75·9	5·06	8064	216	180	9·00	15,749	421	351	14·0
4,250	1050	28·1	23·4	2·34	3542	94·9	79·1	5·27	8396	224	187	9·35	16,392	439	366	14·6
4,500	1090	29·2	24·3	2·43	3680	98·5	82·1	5·47	8722	233	194	9·70	17,036	456	380	15·2
4,750	1130	30·2	25·2	2·52	3815	102	85·1	5·67	9042	240	202	10·1	17,661	473	394	15·8
5,000	1170	31·3	26·1	2·61	3947	106	88.1	5·87	9357	251	209	10·4	18,215	488	407	16·3
6,000	1321	35·4	29·5	2·95	4458	120	100	6·67	10,566	283	236	11·8	20,637	553	461	18·4
7,000	1464	39·2	32·7	3·27	4940	132	110	7·33	11,710	313	261	13·0	22,870	612	510	20·4
8,000	1600	42·8	35·7	3·57	5400	145	121	8·01	12,800	342	285	14·2	25,000	670	558	22·3
9,000	1731	46·3	38·6	3·86	5841	156	130	8·67	13,846	371	309	15·4	27,042	724	603	24·1
10,000	1857	49·7	41·4	4·14	6266	167	139	9·27	14,853	398	332	16·6	29,010	778	648	25·5
12,000	2096	56·2	46·8	4·68	7076	190	158	10·5	16,772	449	374	18·7	36,760	877	731	29·2
14,000	2324	62·3	51·9	5·19	7842	210	175	11·7	18,588	498	415	20·7	46,305	972	810	32·4
16,000	2540	68·0	56·7	5·67	8572	229	191	12·7	20,320	544	453	22·6	39,684	1063	886	35·4
18,000	2748	73·6	61·3	6·13	9272	448	207	13·8	21,980	589	491	24·5	42,294	1150	958	38·3
20,000	2948	79·0	65·8	6·58	9948	266	222	14·8	23,580	631	526	26·3	46,048	1233	1028	41·1
22,000	3140	84·0	70·0	7·00	10,600	283	236	15·7	25,124	673	561	28·0	49,072	1314	1095	43·8
25,000	3420	91·6	76·3	7·63	11,542	310	258	17·2	27,359	733	611	30·5	53,436	1432	1193	47·7

for the purposes of mercantile tabular reference, as is now being done for publication.

Having thus explained the use and application of Tables C and D and the Diagram E, it will be perceived that the task which I have undertaken on this occasion is to show palpably, by comparison with these tabular statements, based on data within the limits of already realised results, taken as a standard, what is the character of steam-ships as respects their locomotive or dynamic capabilities, with reference to the economic performance of mercantile transport service, so far as dependent on the consumption of fuel, thus affording an exposition whereby persons interested in steam shipping, either as owners or directors, or agents, or as charterers of shipping for government or for private service, though unacquainted with the details of marine engineering as a science, may be enabled to arrive at some definite appreciation of the amount of work that may be expected

E.

Diagram showing approximately the Nautical Mileage Consumption of Fuel, for Vessels from 1,000 tons displacement, up to 25,000 tons, the Co-efficients of Dynamic Performance deduced from the formula $\frac{V^3 D^{\frac{2}{3}}}{\text{ind. h. p.}}$, being assumed to be 250, and the consumption of coals being assumed to be at the rate of $2\frac{1}{2}$ lbs. per ind. h. p. per hour.



of steamers; that is, the weight of cargo they will carry, and the length of passage capable of being performed at any definite speed, for, as before observed, the dead weight of cargo that a ship will carry is equal to the tons' weight of water displaced between the light and load water-lines of the ship, less the weight of coals required for the voyage, and which for long voyages commonly amounts to four times the weight of cargo chargeable as freight, and it constitutes the limitation of distance which the ship is able to run under steam at a given speed. This inquiry is therefore essential to a due appreciation of the economic consequences which are involved in progressive variations of steam ship speed, especially as respects the high rates of speed, which are occasionally professed, but which are seldom realized, simply because there has been no recognised exposition, whereby such pretensions may be judged of with reference to the required consumption of fuel. In short, regarding this matter as a public cause, affecting as it does the pecuniary interest of the public to the extent of millions sterling per annum, my object is to promulgate, through the medium of the notoriety which every inquiry obtains upon its being brought before the "British Association for the Advancement of Science," a Mercantile Steam Ship Expositor, by reference to which, as a standard of comparison, the good or bad qualities of steam shipping may be determined; and this surely is a public cause, for by the operation of this scrutiny which such a system of comparative exposition may be expected to inaugurate and popularise, steamers will soon become marketable, with reference, in great measure, to their capabilities for economic transport service, according to the speed that may be required; and under the influence of this scrutiny all bad types of form and vicious adaptation of mechanical system, will be eradicated; incompetency in steam-ship management will become gradually eliminated, and the mercantile transport service of the country being then performed exclusively by good, well-appointed, and well-managed ships, would be performed at a minimum of cost to the shipping interests, and consequently to the best advantage for the interests of the public. Hitherto the dynamic character of steam-ships has been a mechanical problem enveloped in undefined and even delusive terms of shipping and engineering art; consequently its determination has not been based on any recognized principles of calculation. Hence the dynamical character of shipping has been a mystery—a matter of mere assertion on the one hand, and of credulity on the other. But mystery being unveiled, commercial vision will be opened, and competition, in shipping as in any other well understood and open field of public enterprise, will ensure the mercantile transport service of the country being performed to the best advantage, and it will gradually establish and preserve the just equilibrium of trade as between the carriers and consumers of all the sea-borne productions of the earth.

Woolwich Dockyard, 1st September, 1859.

WESTMINSTER BELL.

A writer in the *Times* says:—

"Drill a hole at the extreme end of the crack, and run a whip-saw from the rim of the bell along the course of the fracture, and Big Ben will be himself again. I have tried this plan with perfect success.

"The reason a cracked bell sounds like no other earthly music is owing to the surfaces of the crack grating and hitting against each other with every vibration passing through them, and thus breaking and destroying the continuity of the wave.

"The key or pitch will not suffer, and the bell itself be rendered less likely to break or crack again, as the tension of its particles will be to this exent at least liberated. I

am convinced the timbre or quality of tone will not be lessened, and as the expense will be a mere trifle, it will be worth trying, if only as an experiment, not likely again to offer on so large a scale."

Such a course, it is understood, is frequently adopted with small bells, and has been found to answer perfectly.

Home Correspondence.

LONDON MECHANICS' INSTITUTION.

SIR,—I have the pleasure to inform you that the purchase of our landlord's interest in the buildings occupied by this Institution has been this day completed, and Lord Brougham and his co-trustee are thus released from their liability to pay a rent of £229 per annum for more than a hundred years. This gratifying result is in a great measure due to the invaluable assistance which we obtained from the press at an early period of our labours. But although much has been accomplished, much still remains to be done, as the subscriptions amounted to about £2,000 only, out of the £3,500 required, and the £1,500 additional having been raised by mortgage, Lord Brougham and his co-trustee have been obliged to enter into a covenant for payment of the amount. In order to complete the work which they have thus far carried on successfully, the Committee propose to raise further subscriptions, sufficient to pay off this debt of £1,500, and the necessarily large legal expenses incurred by the trustees, and in this effort they trust to receive a continuance of the powerful assistance which the press has hitherto afforded them.

I have the pleasure to state that the Institution is in an improving condition. There are now upwards of 340 subscribers, besides several hundred persons attending classes in geometry, book-keeping, French, Latin, German, arithmetic, English grammar, drawing, and many other branches of education. There can be no doubt that the utility of the Institution will be greatly increased, now that it has been liberated by the generosity of the subscribers from the payment of £125 of annual rent. £75 more would be extinguished by the payment of the mortgage debt.

I am, &c.,
(On behalf of the Donation Fund Committee),
THOS. J. PEARSALL, Sec., &c.

London Mechanics' Institution,
Oct. 4, 1859.

THE WESTMINSTER CLOCK.

SIR,—So soon as the quarter-chimes had been set going and the hands had been placed on all the dials, I thought it desirable that some efficient steps should be taken to obtain a correct rate of the clock's performance, and therefore proposed to Mr. Quarm to fix up an astronomical clock in his office, at the Houses of Parliament. To this proposal Mr. Quarm at once acceded, and cheerfully undertook the task of observing the rates.

One of the finest astronomical clocks that I have produced was consequently selected, and placed in Mr. Quarm's office on 28th September; and in order to afford additional confidence in the results, I attended personally to the fixing, and adjusting of the pendulum and arc spring, &c. The whole of the adjusting did not occupy two hours, and it may be remarked that the clock at once went to absolute mean time within eight-tenths of a second a day without subsequent regulation. The next step was to ascertain by trial the degree of accuracy which Mr. Quarm was likely to attain in taking the rates; several comparisons of the first blow of the quarter chimes with the astronomical clock were consequently made by him, simultaneously with those made by myself, and the results each time were within two-tenths of a second.

These arrangements having been completed, the following rates of the Westminster clock were taken by Mr. Quarm, from the first blow of the quarters and the first blow of the hour:—

1859.	Time of Observation.	Westminster Clock, Fast or Slow of Astronomical Clock.	Difference in Gain or Loss of Westminster Clock from one observation to the next.
	H. M.	s.	s.
Sept. 29.	10 30	S. 9·8	
„	10 45	S. 10·2	L. 0·4
„	11 0	S. 4·0	G. 6·2
„	12 0	S. 4·0	0·0
„	12 15	S. 2·6	G. 1·4
„	12 30	S. 10·2	L. 7·6
„	1 0	S. 4·4	G. 5·8
„	1 30	S. 12·8	L. 8·4
„	1 45	S. 12·8	0·0
„	2 0	S. 4·2	G. 8·6
„	2 15	S. 2·4	G. 1·8
„	2 30	S. 10·2	L. 7·8
Sept. 30.	10 45	S. 9·0	
„	12 0	S. 4·0	G. 5·0
„	12 15	S. 6·2	L. 2·2
„	12 30	S. 12·2	L. 6·0
„	12 45	S. 8·4	G. 3·8
„	1 45	S. 9·0	L. 0·6
„	3 0	S. 6·2	G. 2·8
„	3 30	S. 11·6	L. 4·4
„	4 30	S. 8·0	G. 3·6
Oct. 1.	10 30	S. 11·6	
„	11 0	S. 3·6	G. 8·0
„	12 30	S. 7·6	L. 4·0
„	1 0	S. 5·0	G. 2·6

No rates were taken after this time, in consequence of the hour and quarter parts being stopped, on account of the fracture of the great bell.

It will be observed, in the foregoing table, that instead of the clock proclaiming Greenwich time within one second in 24 hours, according to the stipulated conditions, it occasionally varies more than eight seconds in a quarter of an hour.

In order to eliminate the error of the astronomical clock I have looked over several years' rates of it, taken by the late Mr. Belville, of the Greenwich Observatory, to ascertain the probable quantity, and found it to amount to rather less than two hundreths of a second for the longest interval between the observations recorded in the Westminster rates.

Besides the above, I have other rates which were previously taken by myself, with a chronometer, on Sept. 12, 13, and 28, and they show that the Westminster clock did not indicate time more accurately on those days.

In my letter, dated July 30, published in the *Mechanics' Magazine* and *Journal of the Society of Arts* (p. 643), it is stated, as my settled conviction, founded on a patient and elaborate investigation of the going part, that the clock could not possibly keep time within the promised limit unless the construction were radically altered and the principle introduced which I then described. It will now be seen that the amount of error shown in the present rates more than fulfils the quantity I then prophesied.

E. T. LOSEBY.

11th October, 1859.

P.S.—To those not intimately acquainted with horo-

logy it may be explained that the arc-spring is an improvement for causing the long and short arcs of vibration of the pendulum to be performed in equal times. It was invented by me, and submitted to trials under the superintendence of the Astronomer Royal at the Greenwich Observatory, during the years 1851 and 1852, and Mr. Airy's reports thereon to the Government may be found in Parliamentary Return to the House of Commons, No. 1006, Session, 1853.

Proceedings of Institutions.

Crosby Hall (Evening Classes).—On the 26th Sept., Mr. Alderman Carter presided in Crosby-hall, and the Annual Report having been read, the Session was declared to have commenced. A vote of thanks to the Alderman was proposed by Mr. Shipton, of the Young Men's Christian Association, and seconded by Mr. Whittington. The number of tickets issued on the first day of term was 100, and on the second day 113. The report records the continued success of the classes, and the steady progress of the cause of adult education. Influenced by the example set in the metropolis, there are numerous towns and villages which have made some effort to establish, in a systematic form, either evening schools or evening classes. In some cases the exertions have been very limited; but during the winter months, at least, the clergy have thrown open their school-rooms for this purpose; and in innumerable cases have dedicated their time and energies, for one or more evenings in the week, to collect around them the young men of the place, and supply them with that particular kind of knowledge which they felt they most required. In the Metropolitan Evening Classes the number of the members has been increased, but the receipts from them are nearly identical with those of 1857-8, viz. :—Michaelmas Term, 796 members; Lent Term, 816; Trinity Term, 654;—producing £614 1s. 2d. Thirty lectures have been delivered, and two choral demonstrations and three elocutionary entertainments held; and all who have taken part in these deserve the best thanks of the community. The Evening Classes this year obtained the honour of the personal patronage of H.R.H. the Duke of Cambridge, who presided at the festival in Willis's-rooms, on the 6th of April; and who, by his speech on the occasion, attracted public attention to the duty of encouraging efforts of this character to render the young men of England more fitted for the duties that await them. The immediate result of this was a liberal subscription round the table; and the effect, less seen but not less real, was the encouragement to all parties actively concerned to continue their labour of love. The great expense of rent and taxes, as in former years, was the difficulty with which the committee had to contend. The young men have given no trouble; the class teachers have been faithful, punctual, and diligent; the lecturers have been generous and talented; but with so great a demand upon the purse it has not been found possible to render these classes self-supporting; and the Committee has again been compelled to resort to the reserved fund for help, in the hopes of finding some day occupation of the rooms, which would eventually prove remunerative, and at the same time provide fresh pupils for the classes. The Report says that it may well be doubted whether institutions of this character can ever sustain themselves while they use their dwelling both night and day, and are consequently taxed with the entire rent; whereas their receipts are derived only from the evening occupants. Under these circumstances, the idea of leaving Crosby Hall appears to be in contemplation. The importance of the classes, says the Report, is now so widely felt, and they have taken such deep root in the pubilc mind, that there is every reason to hope their class rooms will be multiplied, and their reading room transplanted without injury; and though slow to make the change unless necessary, the Committee have its eye on localities and buildings which will be found not less convenient or accessible for the young men of London. Under the present direction there are larger French and German classes than can be found elsewhere in London. There is no other institution with such extensive or well arranged systematic teaching in mathematics, in languages (ancient and modern), and in the requisite training for mercantile pursuits. Since September last, Mr. E. G. Clarke, A.A., has been appointed to a clerkship in the East India House, after a competitive examination; and at the distribution of prizes and certificates to students of Evening Classes at King's College, nine members of the Metropolitan Evening Classes obtained eight of the former and twelve of the latter; and at the Society of Arts Examination in May last, two prizes and 33 certificates were awarded to members of the Evening Classes. The following are the subjects taught in the classes:—French, German, Elocution, Latin, Arithmetic, Book-keeping, Spanish, Vocal and Choral Music, Writing, English Grammar, Algebra, Concertina, Geometry, Italian, Chemistry, English History, Greek, Shorthand, Geography, Bible (free). There are now upwards of 800 students.—On Friday, the 7th instant, there was a public meeting at Crosby Hall, for the purpose of distributing the prizes and certificates obtained this year at the Society of Arts, by members of the Metropolitan Evening Classes for Young Men. The Right Hon. the Lord Mayor occupied the chair, and was supported by the Right Rev. the Lord Bishop of British Columbia; the Rev. Henry Mackenzie, Prebendary of Lincoln; the Rev. M. W. Lusignan; Mr. Thos. Winkworth, Vice-Pres. of the Society of Arts; Mr. D. Blenkharm, and the Hon. Secretaries, &c. There were many ladies present.—The Rev. Charles Mackenzie, one of the Hon. Secretaries, congratulated the meeting upon the presence of the Lord Mayor and other distinguished friends of the Evening Classes, and upon the honourable position which the members had obtained at the recent examination by the Society of Arts. It appeared that two prizes and thirty-three certificates had been awarded to twenty-five members of the Institution in May last, the prize-men being Mr. Samuel Lee Cressall, first prize, German; and Mr. Henry Legg, second prize, French. These gentlemen, having been separately introduced, were suitably addressed by the Lord Mayor, and were presented with their certificates and the cheques of the Society for the amount of their prizes. In consideration also of Mr. Cressall's having obtained a first prize, a cheque for five guineas had been presented by the Council of the Society of Arts to the Metropolitan Evening Classes. In the course of his Lordship's address to Mr. S. L. Cressall, he observed upon the advantages conferred on the Institutions in Union by the systematic examinations instituted by the Society of Arts, and enlarged upon the benefit to young men, both morally and commercially, who acquired a thorough knowledge of a new language.—At the suggestion of Mr. Mackenzie (who was anxious to spare the Lord Mayor, in his present weak condition of health, all unnecessary fatigue), the remaining certificated members were grouped around the chair, and received their respective papers, with a few earnest and affectionate words of approbation and encouragement. A number of books were handed by the Chairman as the Whittington Prize (in recognition of the services rendered to the members of that class by the Rev. R. Whittington), to Mr. Brady, who was reported by Mr. Reynolds, the teacher of the class and donor of the prize, to have been his most industrious and most successful pupil. Four other books were then given to four other gentlemen who had applied themselves to the same branch of study. At this stage of the proceedings, the Lord Bishop of

British Columbia rose to express the warm interest he felt in the Institution generally, and in the particular proceedings of that evening. He thought great credit was due to these young men, who withstood the temptations to idleness and frivolity offered in a thronged metropolis, that they might wisely devote their time to the pursuits of literature and the improvement of the mind. He was himself about to visit a very distant part of her Majesty's dominions, but he hoped to carry out with him, and engraft on his adopted country, many of the wisest institutions of Great Britain; and the work which was going on there was akin to that which it would be his special duty to promote, viz., the higher education of the mind, and the preparation, through a civilising and elevating process, for the reception of revealed truth and the exhibition of Christian life. He warmly congratulated the young men on the success they had achieved, and reminded the meeting that these youthful candidates for honour had been placed in competition, not only with the whole of London, but with the aroused intelligence of the various Institutions through the length and breadth of the land; and he urged upon the members the importance of time as a preparation for eternity, and the responsibility involved in their improved opportunities.—The Rev. Henry Mackenzie called on the meeting to acknowledge the kindness of the Lord Mayor in giving his presence on the occasion; and expressed his own entire and hearty sympathy with the young men of London. He alluded feelingly to the rumour that the Classes were about to leave Crosby Hall on account of the expense of rent, and expressed a strong conviction that there were many merchant princes in the City who, though grudging the time to manage such an Institution, would not hesitate to give large assistance, rather than risk the dispersion of such extensive Classes, that were conferring incalculable benefits, morally, socially, politically, and spiritually, upon so many hundreds of young men engaged in the warehouses, counting-houses, shops, and factories, immediately around them. —The vote of thanks was seconded by the Rev. W. Lusignan, one of the earliest friends of the Institution, who alluded to the support that the Lord Mayor had given, ten or twelve years ago, in his character as a member of the Common Council, when a grant of £50 had been made to this Institution, in its infancy, by the Corporation of London.—After a suitable acknowledgment, and a suggestion that the young men should ask their employers to support the Committee in their attempt to retain Crosby Hall, the Lord Mayor retired, and his place was occupied by the Bishop of Columbia.—The Rev. C. Mackenzie and the Rev. R. Whittington, the Honorary Secretaries, proposed and seconded a vote of thanks to the Council of the Society of Arts, for the assistance given to the cause of general education by their admirable system of Examinations; and in doing so, paid a high tribute to the fidelity and fairness with which the Examiners performed their work.—This was acknowledged by Mr. Winkworth, a Vice-President of the Society, who begged to thank the meeting for their cordial appreciation of the system of Examinations originated by the Society of Arts, and now so successfully and usefully adopted by the Universities and several departments of Government. The Crosby Hall Evening Classes had, as usual, carried off more than their fair proportion of prizes, and if not quite so many in number as last year, the competition being greater and the prizes offered rather fewer, the quality of merit was not deteriorated. If the Society might venture to claim a diadem of honour for inaugurating so important a social desideratum, the Crosby Hall Classes certainly supplied one of its most brilliant gems.—Thanks to the Tutors were then proposed by Mr. E. G. Clarke, A.A. (who in the course of last year had obtained a clerkship at the East India House, after a competitive examination, and who on every previous year had been one of the prize men at the Society's Examinations), and seconded by Mr. Brady, who paid a special tribute to Mr. T. Reynolds and the Rev. Mr. Potter. This was acknowledged by Dr. Zerffi, the German teacher, who was received with great applause; and after a cordial vote of thanks to the Bishop of Columbia, the meeting was dismissed with his Lordship's blessing.

London Mechanics' Institution.—The distribution of the Society of Arts' certificates to the members of the London Mechanics' Institution took place on Wednesday, the 5th inst., in the presence of a crowded auditory. Mr. T. A. Reed, who distributed the certificates, alluded to the beneficial effects of the examinations instituted by the Society of Arts, explained their *modus operandi*, and commended them to the attention of the members. He referred to the work of preparation as a beneficial mental exercise, and expressed a hope that the result of the last examination would give to the successful competitors the encouragement which was due to diligent study, and stimulate them to renewed efforts. Eight out of the nine members passed by the Local Board had succeeded in obtaining one or more certificates, a proportion honourable alike to the Institution and the candidates. Prizes of books were also distributed by Mr. Reed to the successful competitors at the recent examination by the Local Board of several of the classes of the Institution; and it was announced that Mr. Vallentine, a member of the Board, had offered the like number of prizes to be competed for next year. The following candidates received their certificates:—J. B. Rundell, Geometry and Mensuration (1st class), with first prize; James Dickie, 3rd class, Arithmetic and French; F. Aumonier, 2nd class, French; W. W. Woolnough, 3rd class, Arithmetic and French; R. E. Woods, 2nd class, Geography; F. Moore, 3rd class, Book-keeping; Thomas Shinn, 2nd class, Chemistry; W. M. Medcraft, 3rd class, Geography. The prizes of books were awarded to Mr. A. Sheill, for writing; Miss Wallington, for English grammar; Mr. Davidson, for landscape drawing; and Mr. Rathbone, for phonetic short-hand.

PATENT LAW AMENDMENT ACT.

APPLICATION FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, October 7th*, 1859.]

Dated 26th July, 1859.

1739. D. B. Hale, New York, U.S.—A new and useful garment for ladies' wear, being a combined waist or body and a skirt supporter and bustle. (Partly a com.)

Dated 5th September, 1859.

2024. J. B. H. H. R. Barre, and J. B. M. E. Barre, Paris—Imp. in cutting out or engraving metals and their alloys.

Dated 9th September, 1859.

2058. M. M. Jackson, Zurich, Switzerland—Imp. in generating steam for condensing engines.

Dated 13th September, 1859.

2086. E. A. F. Lebourgeois, Suresnes, France—An improved machine for providing with pin points the blocks employed for surface printing on calico, paper, or other similar materials.

2088. A. B. Freeland, Camden-road Villas, Middlesex—Imp. in preparing hay and clover for food for horses and other animals.

Dated 14th September, 1859.

2092. J. Marritt, Sutton, Yorkshire—An improved double-action rotating harrow.

2094. R. C. Rapier, Newcastle-upon-Tyne—Imp. in the construction of steam boilers.

2096. N. Defries, 5, Fitzroy-square, Middlesex—Imp. in gas meters.

2098. E. Applegath, Dartford—Imp. in machinery for printing and for cutting printed paper into sheets.

Dated 15th September, 1859.

2100. J. Addenbrooke, London—An apparatus for wrapping, folding, or packing up goods or parcels.

2102. J. T. Wood, Strand, Westminster—Imp. in printing and embossing dies.

2104. J. P. Clarke, King-street Mills, Leicester—Imp. in the manufacture of spools or reels for the winding on of cotton, linen, thread, silk, or other fibrous materials.

Dated 16th September, 1859.

2106. J. Bottomley and A. H. Martin, North Brierley, near Bradford, Yorkshire—Imp. in means or apparatus employed in weaving.

2108. B. Lauth, Manchester—Imp. in the manufacture of rails for railways.
2112. J. Beck, Coleman-street, London—Imp. in stereoscopes.

Dated 18th September, 1859.

2114. J. Luis, 1B, Welbeck-street, Cavendish-square—Imp. in mechanical hammers. (A com.)
2116. J. Luis, 1B, Welbeck-street, Cavendish-square—An automaton bell for the prevention of collisions at sea. (A com.)
2118. J. Luis, 1B, Welbeck-street, Cavendish-square—Imp. in cooling apparatus for liquids, especially beer. (A com.)
2120. J. J. Kerr, Twickenham, Middlesex—Imp. in the manufacture of cartridges containing shot.

Dated 19th September, 1859.

2124. E. H. Taylor, Saltney, Chester—Imp. in the mode of securing the bolts in fish-joint and other fastenings for rails on railways.
2126. J. Hawkins and C. Hawkins, Walsall—Imp. in fly presses to be worked by steam, water, or other power.
2128. R. McCall, Dublin—Imp. in obtaining precipitates of copper, parts of which improvements are applicable to the production of yellow ochre.
2130. T. C. Eastwood, Bradford—Imp. in means or apparatus for preparing and combing wool, cotton, and other fibres.
2134. W. Clar, 53, Chancery lane—Certain imp. in electro magnetic telegraphs. (A com.)
2136. J. Court, Brompton-row, Middlesex—Imp. applicable to gas and other lamps and lights, and also gas stoves for effecting more complete combustion therein.

Dated 20th September, 1859.

2140. W. McIlwraith, Glasgow—Imp. in weaving.
2142. A. Lamb, Southampton—An improved method of heating the feed water for boilers.

Dated 22nd September, 1859.

2155. T. Field, 5, Rose-gardens, Hammersmith—A new means and system for cleaning, ironing, pressing, and glazing women's stays, corsets, supporting bands, men's jackets, coats, trousers, and waistcoats, chintzs, laundry work (that is to say goods and articles generally washed by laundresses), window blinds and textile fabrics generally.
2157. J. Dales, 11 and 12, Gresham-house, Old Broad-street, London—Imp. in purifying sewage and other impure waters, and in separating therefrom materials suitable for use as manure, and also the preparation of a substance to be employed for such purposes.

Dated 23rd September, 1859.

2159. L. Castelain, 53, Newman-street, Oxford-street, and C. F. Vasserot, 45, Essex-street, Strand—A novel application of a plant to the manufacture of pulp for paper and millboard, and in the method of treating the same when so applied.
2161. C. J. Parry, Manchester—Imp. in diamond shirt fronts.

Dated 24th September, 1859.

2163. J. J. Bourcart, Manchester—Imp. in machinery or apparatus for opening, cleaning, carding, and drawing cotton and other fibrous materials.
2165. A. R. Le Mire Normandy, 67, Judd street, Brunswick-square—Imp. in the application of steam for cooking food.
2167. C. Lambert, Sunk Island, Yorkshire—Imp. in machines or apparatuses for cutting and pulping food for cattle and other like purposes.
2169. T. Robinson, St. Helen's, Lancashire—Imp. in steam hammers.
2171. J. T. Pope, Burslem, Staffordshire—Imp. in the manufacture of marbles.
2173. J. Opie, Tremar, Cornwall—Imp. in instruments or apparatus for charging holes in blasting operations, parts of which are also applicable for like purposes.

Dated 26th September, 1859.

2175. R. W. Sievier, Upper Holloway, Middlesex—Imp. in the means of creating a draught, so as to remove the gases which may be produced by combustion, or from places where gases may be generated where they may be detrimental to health.
2177. D. White, 18, High Holborn—Increasing the illuminating and heating powers of gases, and regulating the flow of gases, and improvement in the material for gas meters, and improvement in glass and cylinder holders.
2179. J. Villet-Collignon and L. George, Paris, 29, Boulevart St. Martin—Imp. in typography.

Dated 27th September, 1859.

2181. W. Airey, Brighouse, and J. Clayton, Golcar, Yorkshire—Imp. in machinery or apparatus for preparing silk, wool, cotton, flax, or other fibrous substances for spinning.
2183. T. Birtwell and R. Marshall, Padiham, Lancashire—An improved arrangement of apparatus to facilitate the putting on of boots to the feet.
2185. J. S. Parfitt, Paris, 60, Boulevart de Strasbourg—An improved machine for heading bolts, rivets, screws, and other similar articles requiring to be headed whilst hot.
2187. T. Beards, Stowe, Buckinghamshire—Imp. in ploughing and cultivating land by steam power, and in machinery used for such purposes.

Dated 28th September, 1859.

2189. W. Maltby, De Crespigny park, Camberwell—An improved mode of producing starch-gum.
2191. E. K. Dutton, Sale, Chester—Certain imp. in "governors," particularly adapted to steam engines.
2193. T. Sutton, St. Brelade, Jersey—Imp. in the construction of apparatus for taking photographic pictures, consisting of and entitled "an improved panoramic lens for taking photographic pictures.
2195. W. H. Phillips, Nunhead, Peckham, Surrey—Imp. in apparatus for generating and regulating heat, applicable to culinary and other purposes.
2197. G. Evans and E. Huxley, 12, Old Cavendish-street, Cavendish-square, Middlesex—Imp. in the construction of hernial trusses and pads adapted to surgical purposes generally.
2199. M. L. J. Lavater, Strand—Imp. in apparatus known as injection bottles, and in pneumatic discs used in apparatus for adhering to glass and other impermeable substances.
2201. D. Stewart, Newcastle-on-Tyne—Imp. in presses used for pressing goods.

Invention with Complete Specification Filed.

2154. E. B. Dimock and J. H. Baker, Ware House Point, Connecticut, U.S.—A new and useful improvement in mechanism or apparatus for drying woollen or other cloths. (A com.) —21st September, 1859.

WEEKLY LIST OF PATENTS SEALED.

[*From Gazette, October 7th*, 1859.]

October 7th.

866. A. Chaplin.
876. W. Campion.
877. M. Wheeldon.
879. M. A. F. Mennons.
881. W. Hooper.
882. W. Hooper.
888. T. Barnett, H. T. Sourbuts, and W. Loynd.
890. J. Hawkins.
893. J. Martin.
905. W. Rowan.
906. R. A. Brooman.
907. W. S. Clark.
909. J. Marland.
912. P. Aitchison.
918. M. Castay.
921. R. A. Brooman.
922. S. Tatton.
923. R. Emery.
928. W. Craft and T. Wilson.
929. A. R. Johnson.
930. J. A. Coffey.
932. J. L. Stevens.
933. J. Hughes, W. Williams, and G. Leyshon.
946. G. Abeillou.
952. H Barrow.
956. W. Clark.
967. J. Luis.
1045. W. E. Newton.
1050. J. H. Johnson.
1067. R. Harrington.
1120. J. G. Willans.
1204. W. S. Thomson.
1270. F. J. Bramwell.
1297. C. E. Amos.
1318. T. Wilson.
1412. W. Sellers.
1552. G. Baker.
1572. E. A. Wood.
1592. A. V. Newton.
1597. W. E. Newton.
1843. J. D. Bryant.
1872. J. Stuart and W. Stuart.

Patents on which the Stamp Duty of £50 has been Paid.

[*From Gazette, October 7th*, 1859.]

September 26th.
2266. W. Smith and N. F. Taylor.

October 4th.
2389. G. W. Varnell.

October 5th.
2352. F. Whitehead.
2358. D. Joy and W. Holt.

[*From Gazette, October 11th*, 1859.]

October 8th.
2380. W. Rennie, junr.

October 9th.
2364. T. King.
2371. L. J. Jordan.
2414. G. Collier.
2446. J. F. Deshayes.
2456. J. Lacassagne & R. Thiers.

Patent on which the Stamp Duty of £100 has been paid.

[*From Gazette, October 7th*, 1859.]

October 1st.
324. T. Restell.

October 3rd.
234. J. Balmforth, W. Balmforth, and T. Balmforth.

October 4th.
280. W. Bissell.
565. W. H. F. Talbot.

October 5th.
330. H. Moorhouse.
400. S. Pincoffs & H. E. Schunck.

[*From Gazette, October 11th*, 1859.]

October 6th.
282. J. Blair.
292. S. Rainbird.
413. C. T. Judkins.
448. J. Otams.

October 7th.
324. T. Restell.

October 8th.
545. C. B. Normand.

LIST OF DESIGNS FOR ARTICLES OF UTILITY REGISTERED.

No. in the Register.	Date of Registration.	Title.	Proprietors' Name.	Address.
4,200.	Sept. 26th.	Iron Keg or Cask, for Packing Paint or other merchandise	Charles Wall	Newton-street, Birmingham.
4,201.	,, 27th.	Economising and Purifying Gas Burner	Armstrong and Hogg	30, Lothian-road, Edinburgh.